

BeAGLE Update

Mark D. Baker

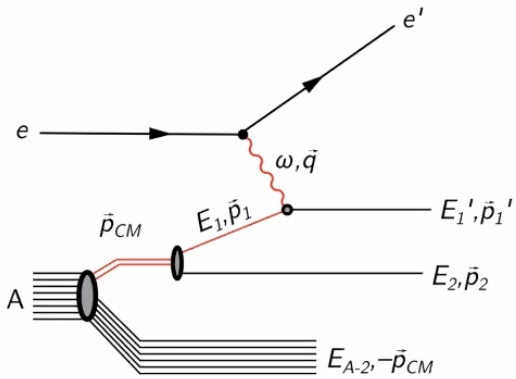
01 April 2021

Bugfix!!
BeAGLE plans

Latest 4-momentum bug is fixed.

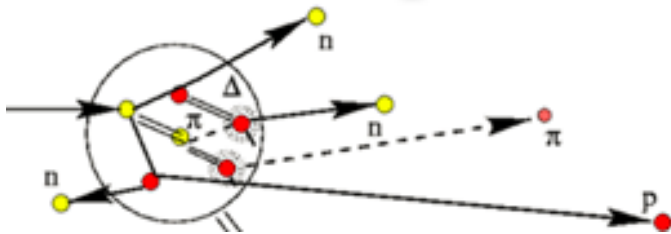
- Easiest to see/debug in quasi-elastic scattering using GCF (Generalized Contact Formalizm).
- Naively, very small impact: ~ 15 MeV.
- Practically much bigger since the error is in E^* where this is a big percentage.
 - Changes the τ_0 tune needed (from 7 to ~ 10 fm/c) by everyone when I release it.
 - Also there in DPMJET-F.

GCF (QE) + BeAGLE!



Primary interaction
input from **GCF!** for
the hard collision.

Primary interaction

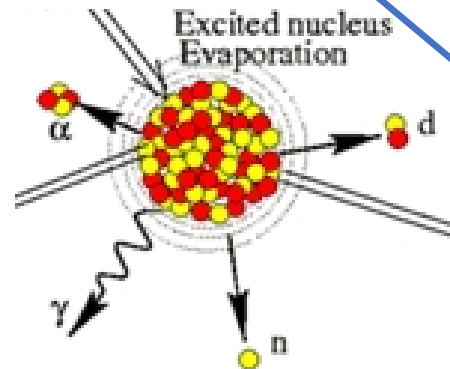


Intra-nuclear cascade

**Nuclear remnant
evaporation & breakup**

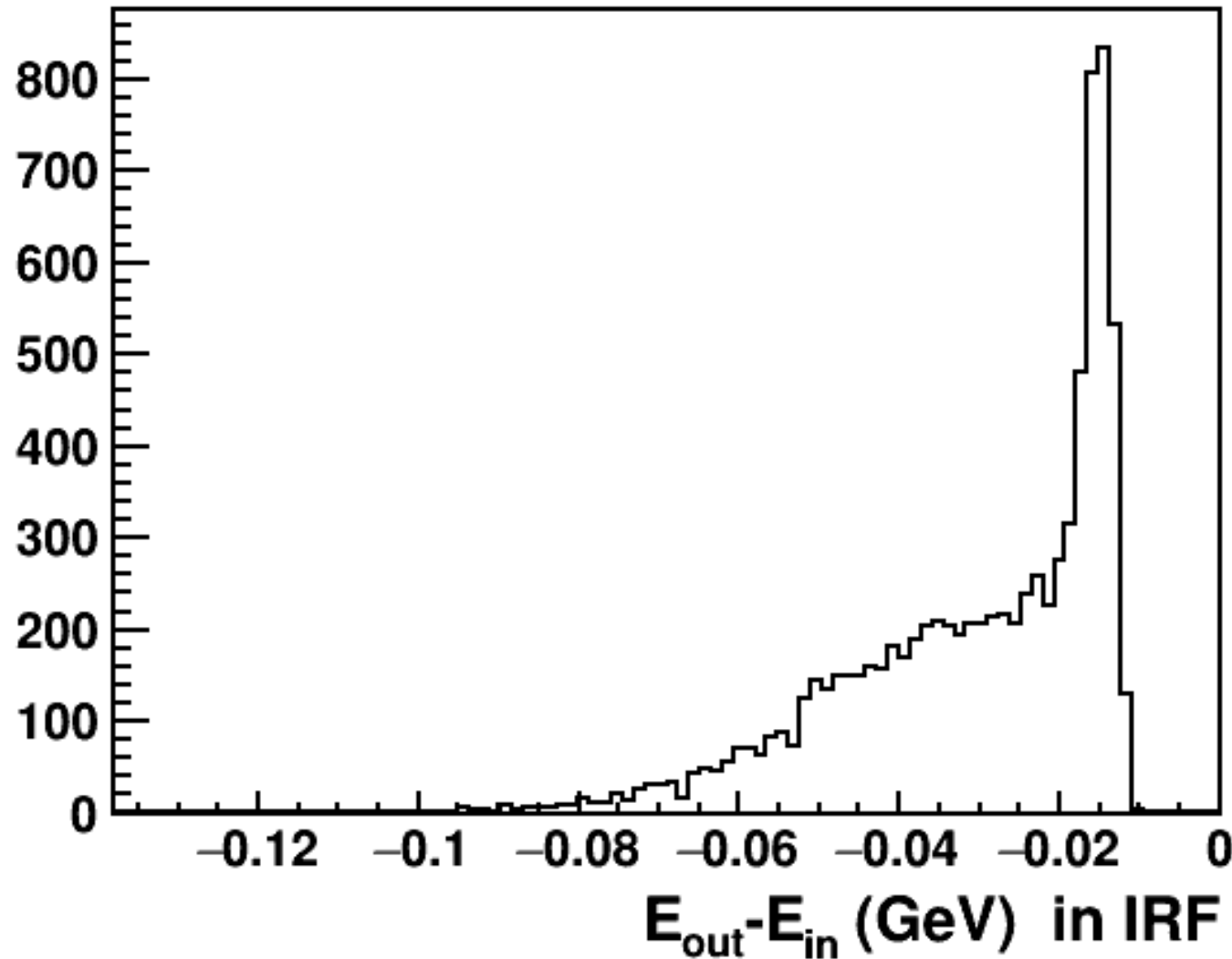
Cascade process
handled by **DPMJET**.
Key parameter τ_0

Nuclear remnant
evaporation and
break up by **FLUKA**.



Recall the bug: 15 MeV error (16 ppm)

eC 880.2 GCF w/BeAGLE = 10 x 41 GeV



(A-2)* is
disassembled &
reassembled

Some events
involve INC

Bug in DT_FICONF: in essence 1 line

```
mdbaker@eic0104:src
File Edit Options Buffers Tools Fortran Help
**sr 27.12.06 new excitation energy correction by A.F.
*
* all parts with Ilcopt<3 commented since not used
*
* still to be done/decided:
*   Increase Icor and put back both residual nuclei on mass shell
*   with the exciting correction further below.
*   For the moment the modification in the excitation energy is simply
*   corrected by scaling the energy of the residual nucleus.
*
      → LLCPOT = .TRUE.
      ILCOPT = 3
      IF ( LLCPOT ) THEN
        NNCHIT = MAX ( INUC ( I ) - NTOT ( I ) , 0 )
        IF ( ILCOPT .LE. 2 ) THEN
C* Patch for Fermi momentum reduction correlated with impact parameter:
C      FRMRDC = MIN ( (PFRMAV(INUC(I))/APFRMX)**3, ONE )
C      DLKPRH = 0.1D+00 + 0.5D+00 / SQRT(DBLE(INUC(I)))
C      AKPRHO = ONE - DLKPRH
C* f x K rho_cen + (1-f) x 0.5 x K rho_cen = frmrdc x rho_cen
C      FRCFLL = MAX ( 2.D+00 * FRMRDC / AKPRHO - ONE,
C      &              0.05D+00 )
C*      REDORI = 0.75D+00
C*      REDORI = ONE
C      REDORI = ONE / ( FRMRDC )**(2.D+00/3.D+00)
        ELSE
          DLKPRH = ZERO
          RDCORE = 1.14D+00 * DBLE(INUC(I))**(ONE/3.D+00)
* Take out roughly one/half of the skin:
          RDCORE = RDCORE - 0.5D+00
          FRCFLL = RDCORE**3
          PRSKIN = (RDCORE+2.4D+00)**3 - FRCFLL
          PRSKIN = 0.5D+00 * PRSKIN / ( PRSKIN + FRCFLL )
          FRCFLL = ONE - PRSKIN
          FRMRDC = FRCFLL + 0.5D+00 * PRSKIN
          REDORI = ONE / ( FRMRDC )**(2.D+00/3.D+00)
        END IF
      IF ( NNCHIT .GT. 0 ) THEN
        REDCTN = ZERO
      END IF
- UU- (DOS) ----F1 dpmjet3.0-5F-new.f 42% L13384 Git-master (Fortran) -----
```

Put LLCPOT on a switch in the FERMICARD.

.FALSE. conserves 4-momentum

.TRUE. does not.

More details: IF LLCPOT is .TRUE.

```
ELSE
  DLKPRH = ZERO
  RDCORE = 1.14D+00 * DBLE(INUC(I))** (ONE/3.D+00)
* Take out roughly one/half of the skin:
  RDCORE = RDCORE - 0.5D+00
  FRCFLL = RDCORE**3
  PRSKIN = (RDCORE+2.4D+00)**3 - FRCFLL
  PRSKIN = 0.5D+00 * PRSKIN / ( PRSKIN + FRCFLL )
  FRCFLL = ONE - PRSKIN
  FRMRDC = FRCFLL + 0.5D+00 * PRSKIN
  REDORI = ONE / ( FRMRDC )** (2.D+00/3.D+00)
END IF
IF ( NNCHIT .GT. 0 ) THEN
  REDCTN = ZERO
  DO 1230 NCH = 1, NNCHIT
    IF (DT_RNDM(PRFRMI) .LT. PRSKIN) THEN
      PRFRMI = ( ( ONE - 2.D+00 * DLKPRH )
        * DT_RNDM(PRFRMI) )**0.33333333333333D+00
    ELSE
      PRFRMI = ( ONE - 2.D+00 * DLKPRH
        * DT_RNDM(PRFRMI) )**0.33333333333333D+00
    END IF
    REDCTN = REDCTN + PRFRMI**2
  CONTINUE
  REDCTN = REDCTN / DBLE (NNCHIT)
ELSE
  REDCTN = 0.5D+00
END IF
EEXC (I) = EEXC (I) * REDCTN / REDORI
AMRCL (I) = AMRCL0 (I) + EEXC (I)
PRCL(I,4) = SQRT ( PTORCL**2 + AMRCL(I)**2 )
END IF
```

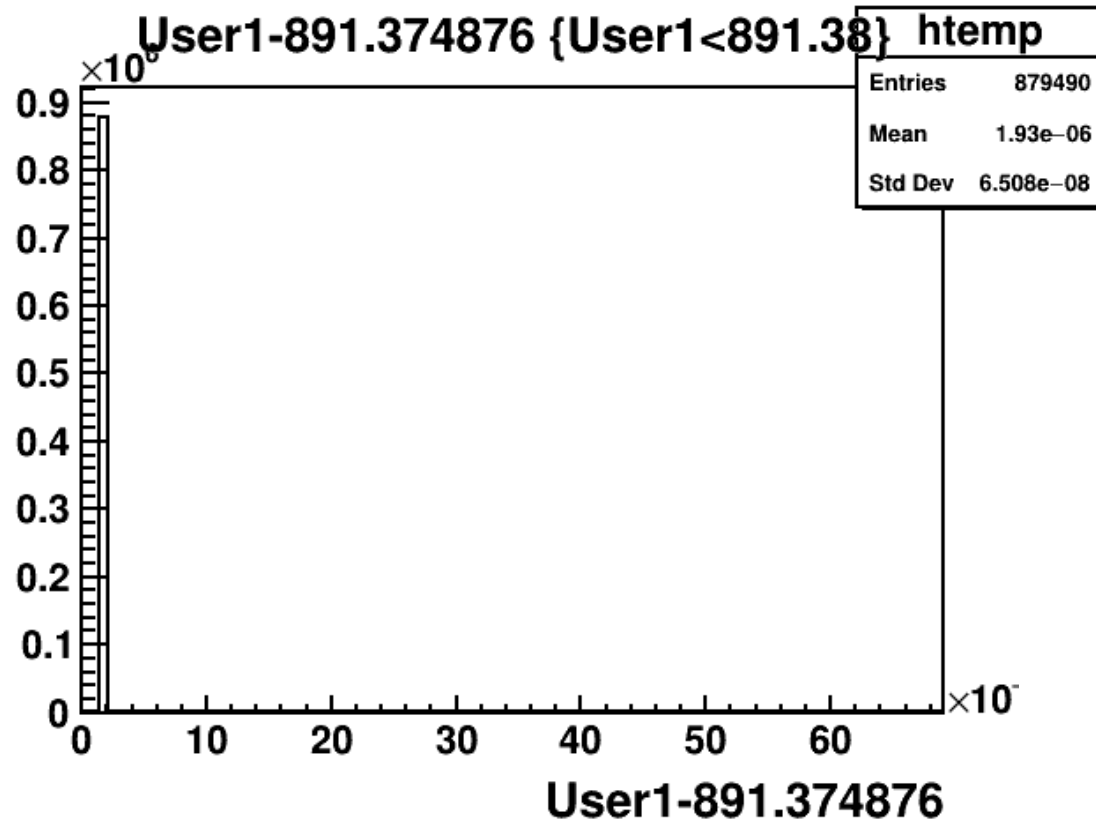
REDORI=1.185
For A=12
Fixed

REDCTN is a
complicated
e-by-e random #

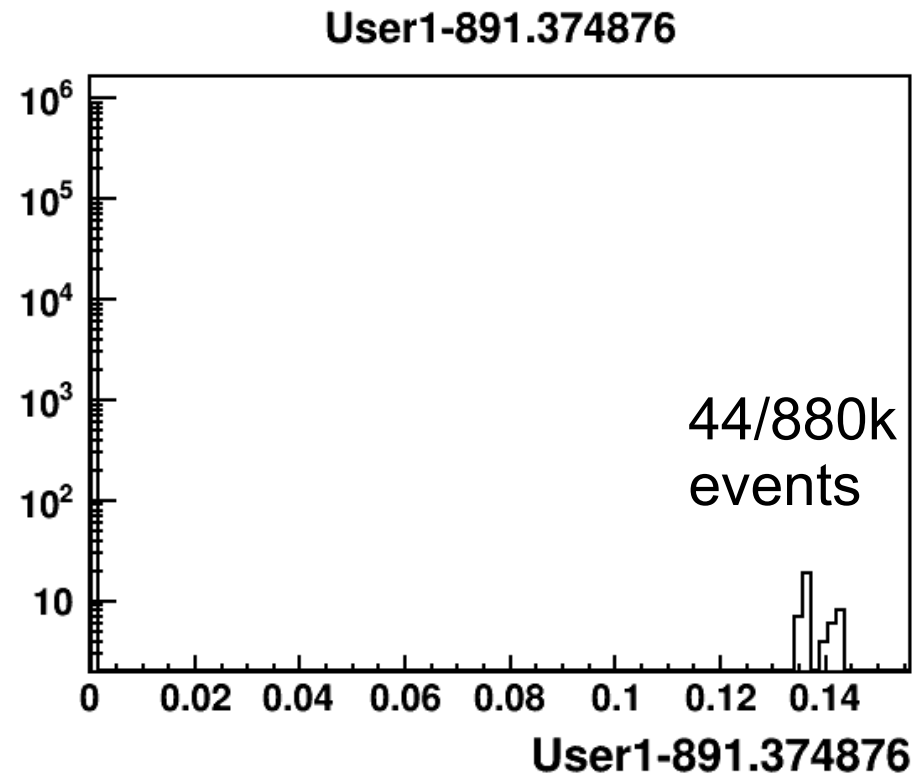
Multiply EEXC by
a random factor
 $0 < r < 1$.

Rescale energy.

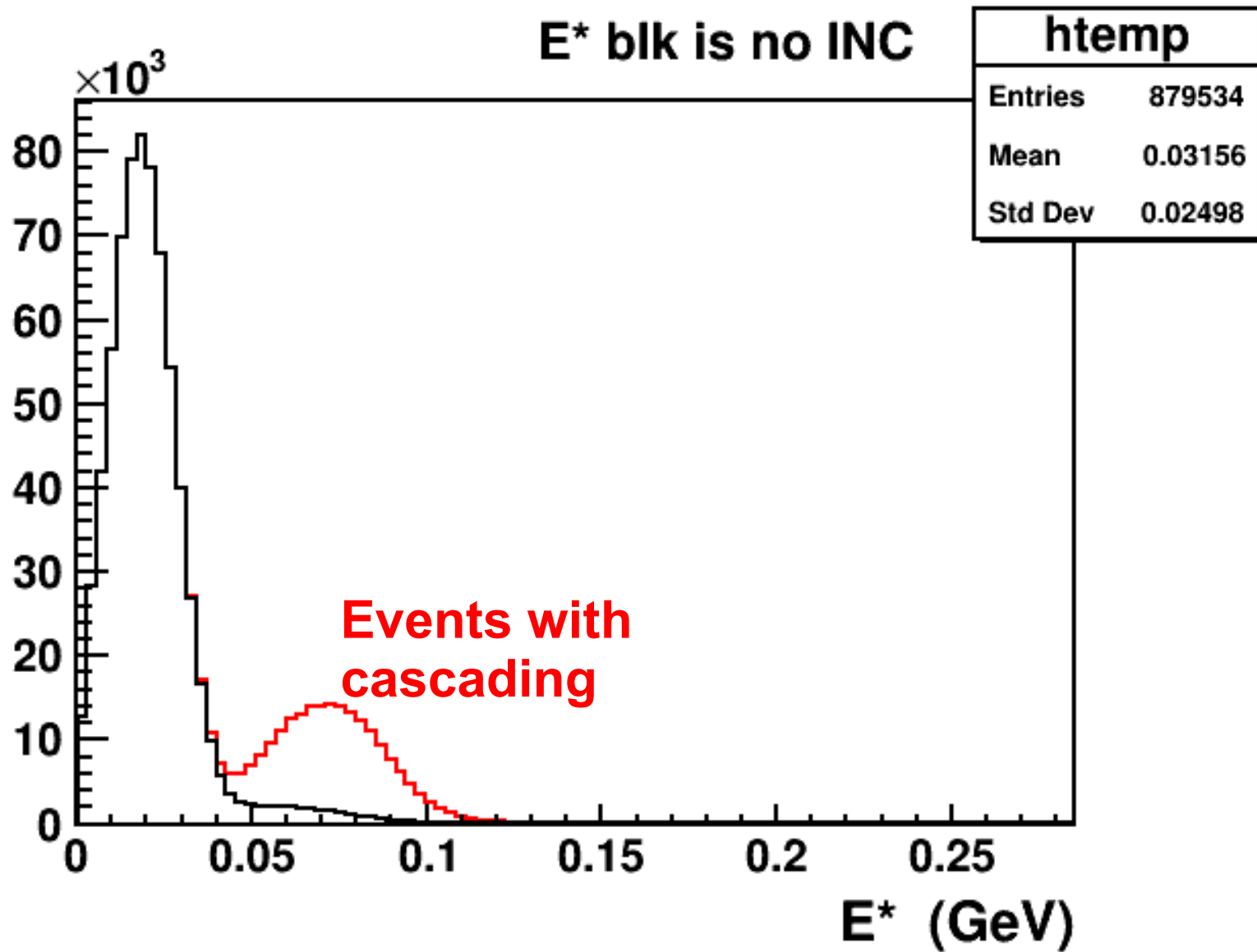
After bugfix



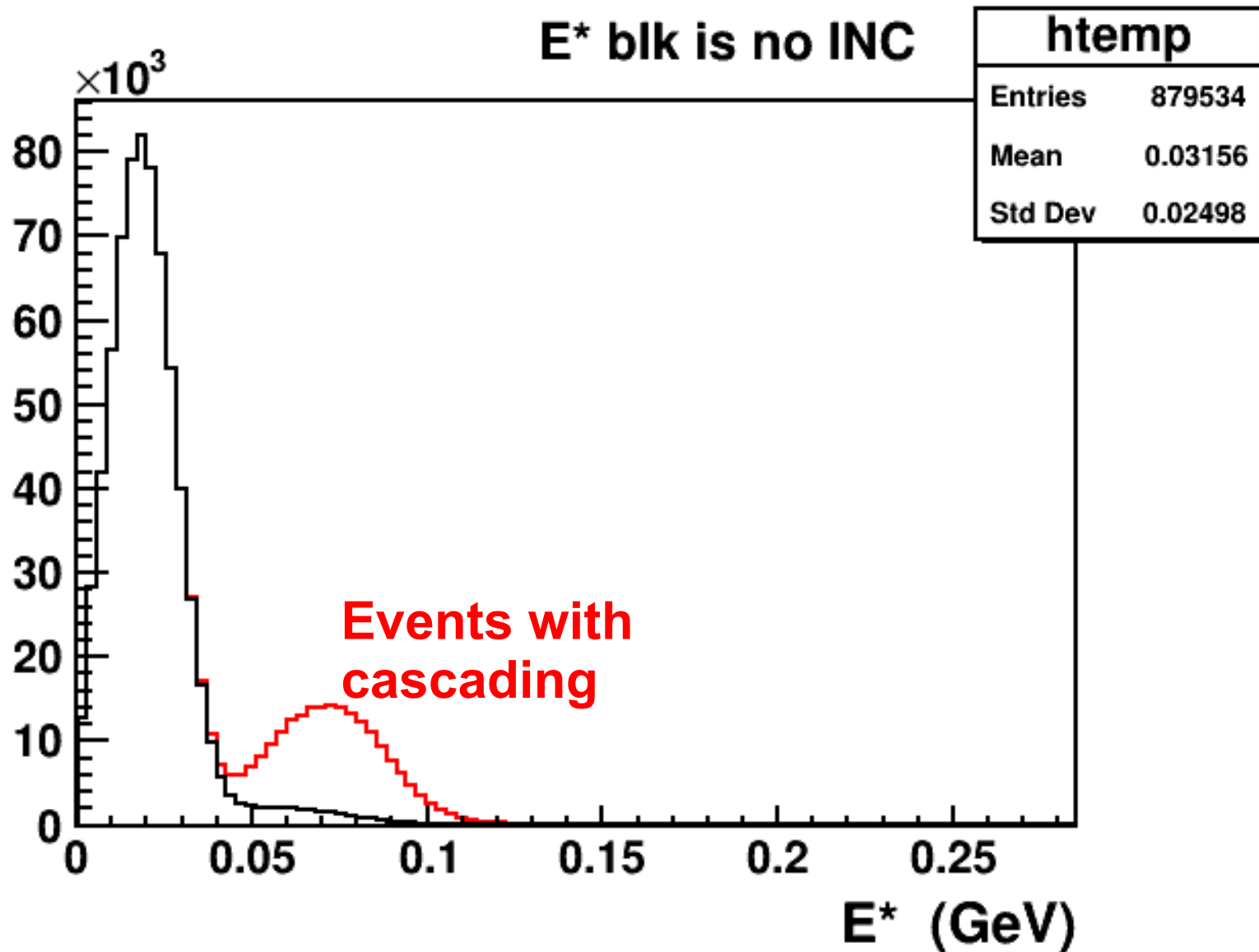
**Error now
0.000002 GeV**



Excitation energy plot



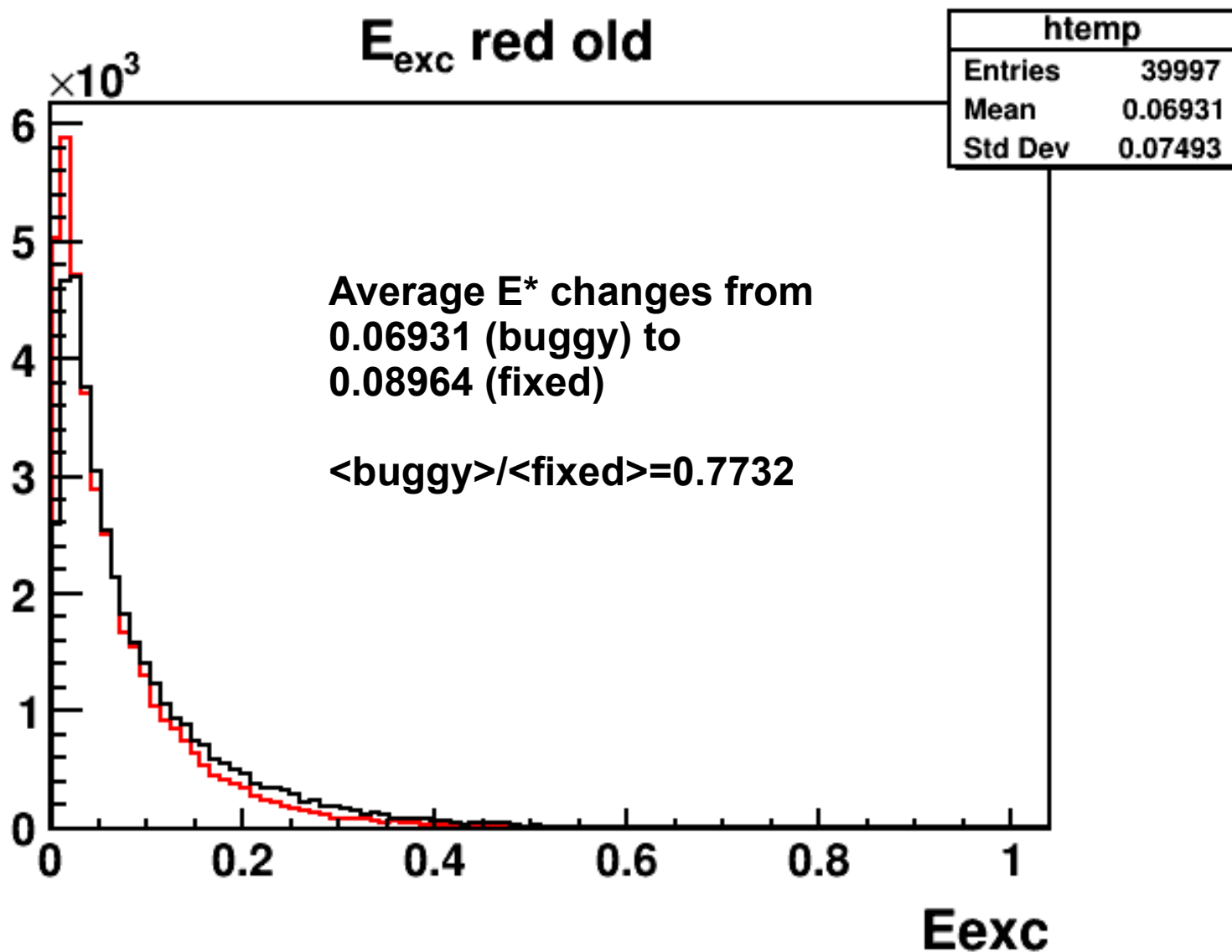
Problem, 0.015 error was in E^* . **Not small!**



Implications

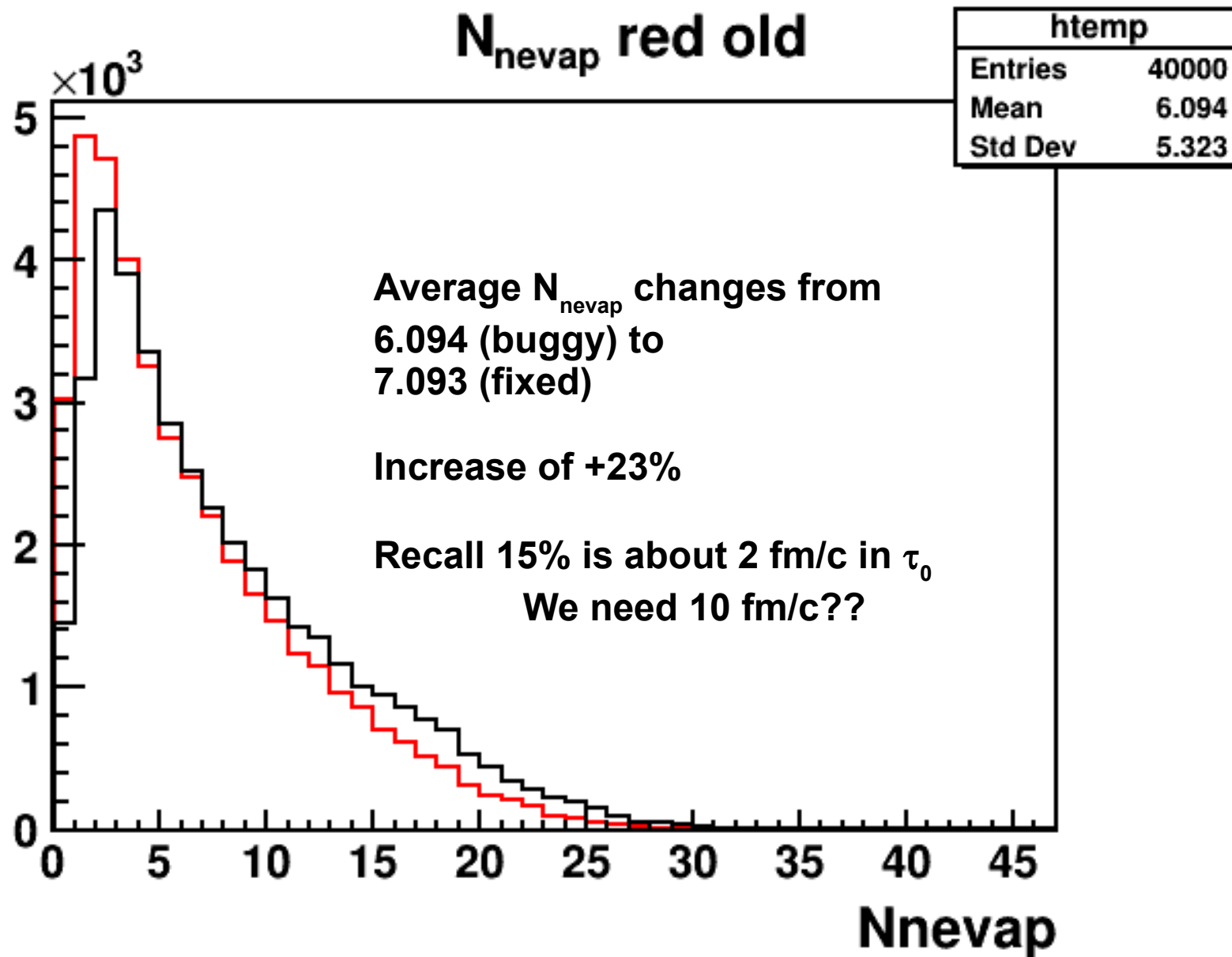
- This bug is in all BeAGLE processes (and in DPMJET-F).
- We tuned to $\tau_0=7\text{fm}$ using E665 neutrons.
- If we fix the bug, it needs retuning.
 - Quick answer: 10 fm
 - Better answer from Wan with new plot of N_n vs v from E665
- Upon release, users must change τ_0 or use the backward-compatibility switch.

Impact of bugfix for E665 μ +Pb

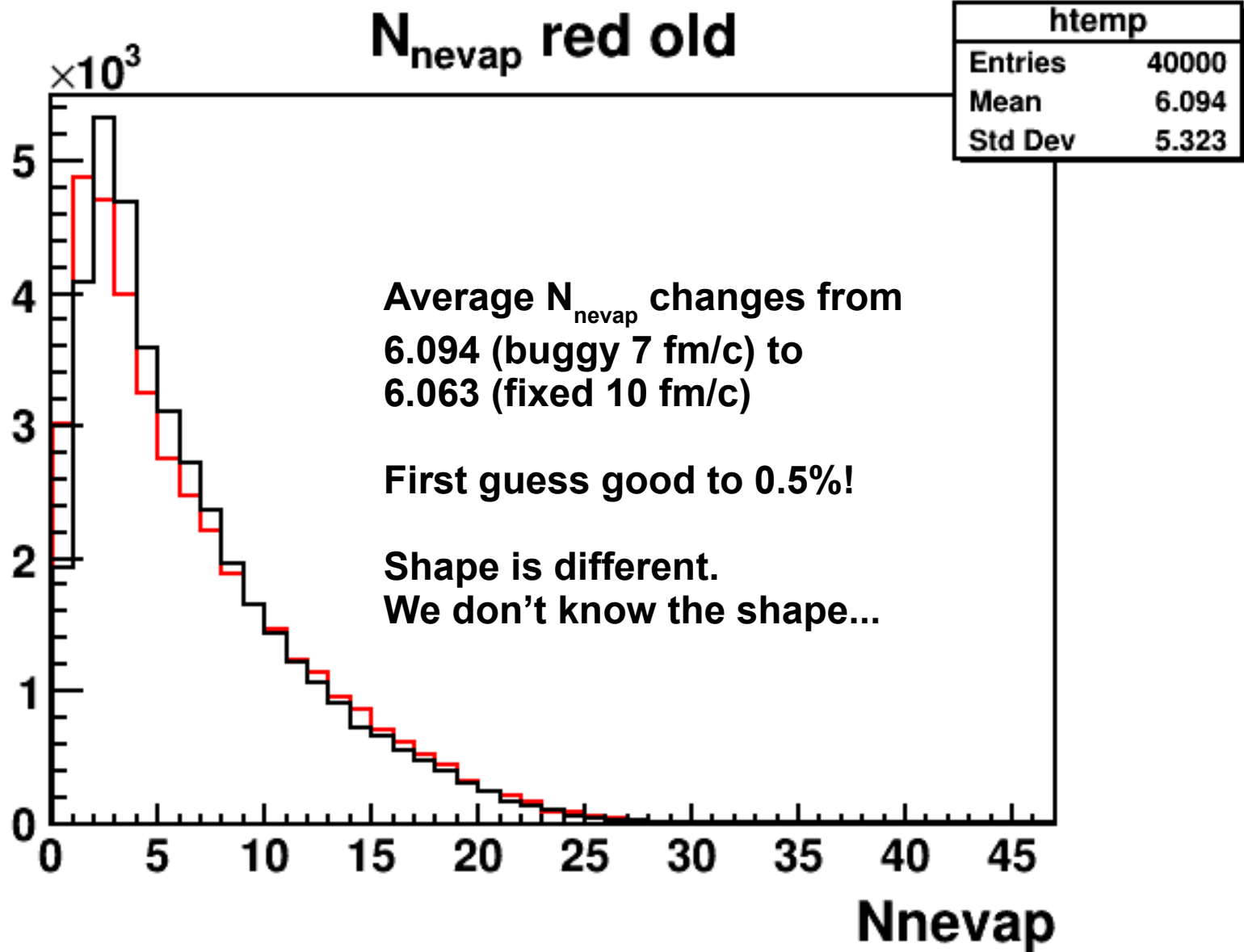


Note: A few high E* events were truncated.

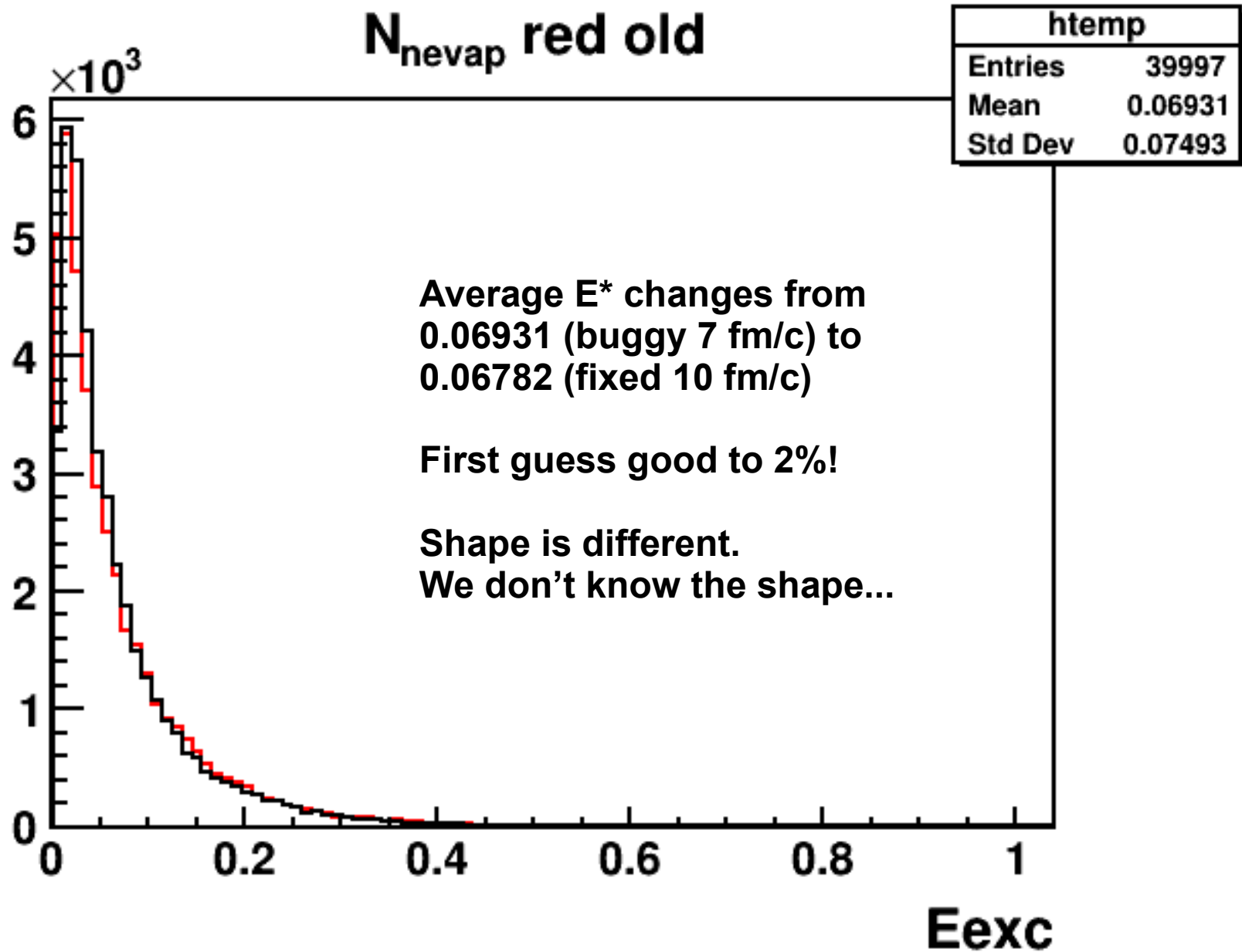
Impact of bugfix for E665 μ +Pb



Try $\tau_0 = 10$ fm/c



Try $\tau_0 = 10$ fm/c

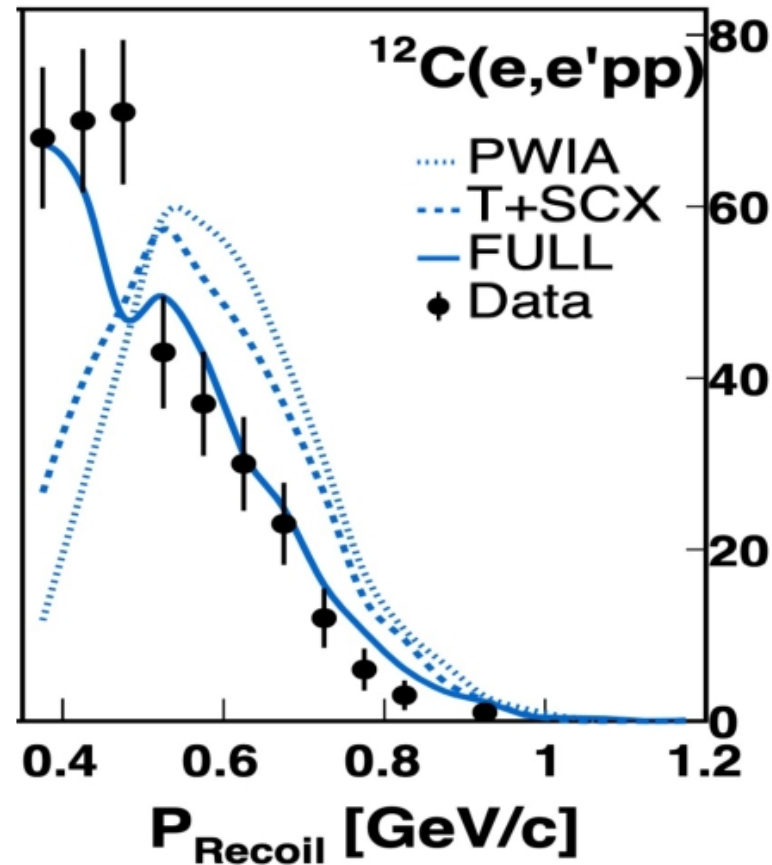


Idea – use JLAB data to test/tune τ_0

- Collaborating with Florian Hauenstein & others
- Release bugfixed BeAGLE & retuned control files.
- Hand back over to Florian
 - 1) Study impact on SRCs @ EIC
 - 2) Can we fit CLAS12 (or other) data with GCF+BeAGLE? **Validate or TUNE τ_0 !**
 - 1) **Simpler process than inelastic+diffractive @ E665**
 - 2) **Better understood data**

Expectation from data & Natalie Wright et al.

Plot taken from Or Hen's slides



JLAB data
compared with
eGENIE

Transport FSI: Excess nucleons at low end of recoil peak.
Washing out the peak.

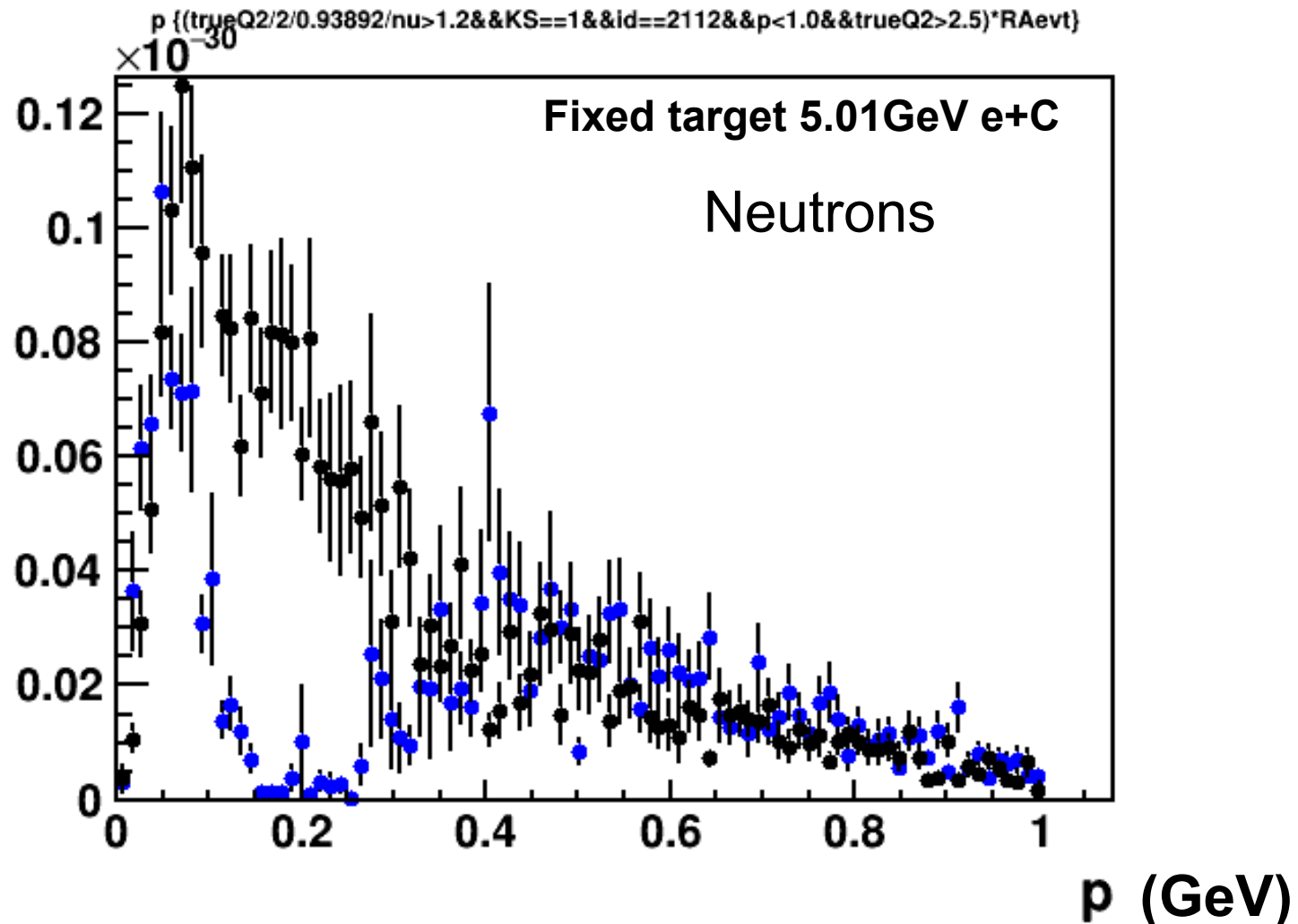
Similar results in BeAGLE

Blue is no INC

$x > 1.2, Q^2 > 2.5 \text{ GeV}^2$

Black is full BeAGLE

$x > 1.2, Q^2 > 2.5 \text{ GeV}^2$



Working on GCF (DIS) + BeAGLE!

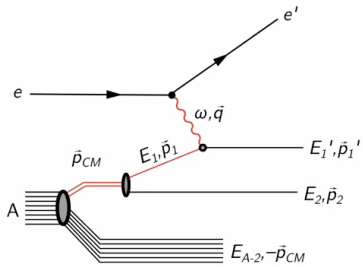
Primary interaction
input from **GCF!** for
the hard collision.

Hadronization handled by **PYTHIA**.

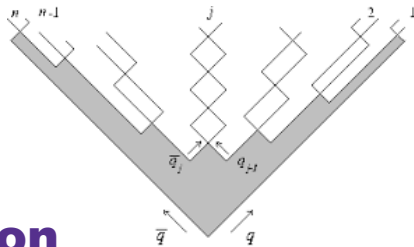
Cascade process
handled by **DPMJET**.

Nuclear remnant
evaporation and
break up by **FLUKA**.

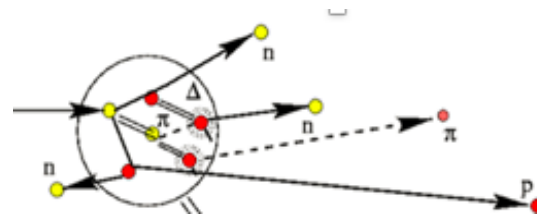
Primary interaction



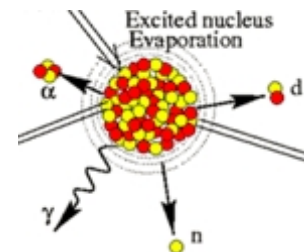
Hadronization



Intra-nuclear cascade



**Nuclear remnant
evaporation & breakup**



Additional Plans

- Desperate need for documentation (including writeup for paper!)
- Need example files for users
- Rationalize BNL executables
 - Kolja's official BeAGLE is always way out-of-date
 - My version is in the "wrong" area